Exceptional service in the national interest

Sandia National Laboratories



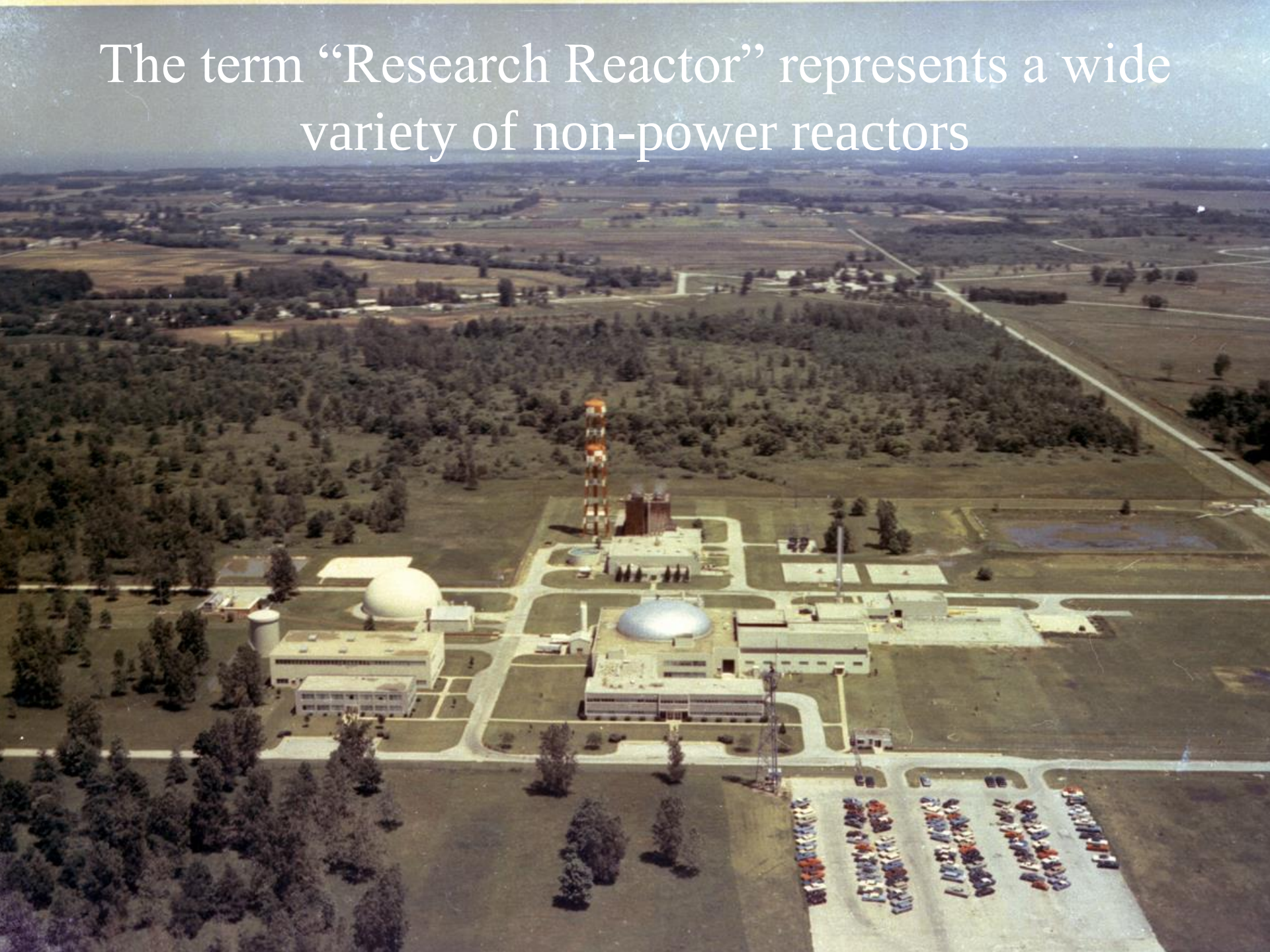
Security Risks of Nuclear and Radioactive Material at Research Reactors

Dave Ek, USA

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

The term “Research Reactor” represents a wide variety of non-power reactors

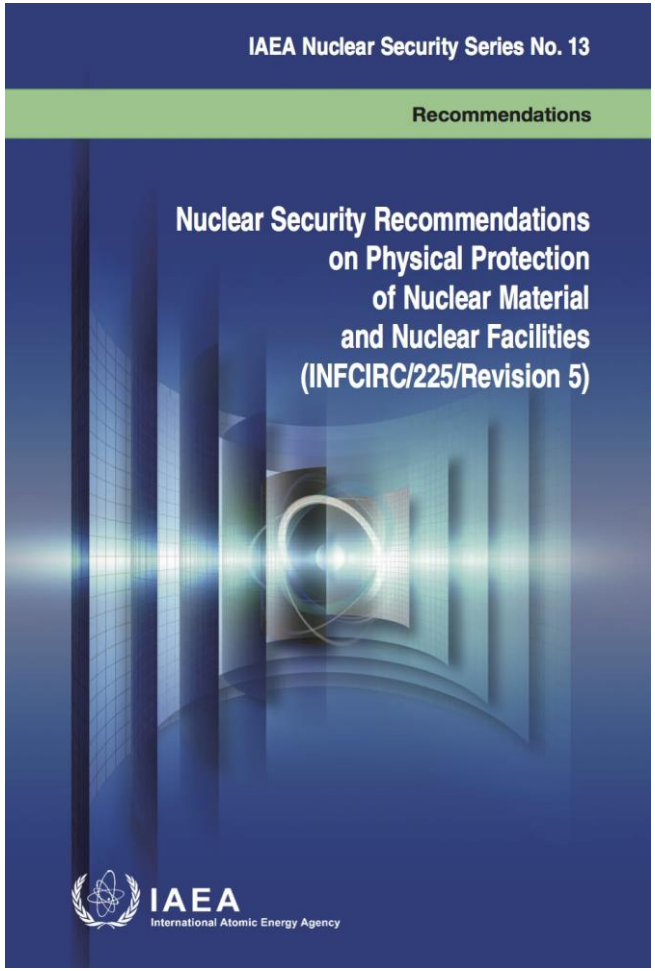


Purpose

- The purpose of the paper is:

1. To discuss the influence and **application** of international security recommendations/**guidance** on Research Reactor and Associated Facilities (RRAF)
2. To discuss the r**isk management** at RRAF, how **risk** is commonly **estimated,** and some potential issues with this estimation; and
3. Summarize on-going work to develop an approach to **comprehensively estimate nuclear security risk** to address these concerns

Security at Research Reactors



- Unauthorized Removal or Sabotage
- Category I, II, III
- URC, HRC

20

TABLE 1. CATEGORIZATION OF NUCLEAR MATERIAL

Material	Form	Category I	Category II	Category III[c]
1. Plutonium [a]	Unirradiated[b]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
2. Uranium-235 (^{235}U)	Unirradiated[b] – Uranium enriched to 20% ^{235}U or more – Uranium enriched to 10% ^{235}U but less than 20% ^{235}U – Uranium enriched above natural, but less than 10% ^{235}U	5 kg or more	Less than 5 kg but more than 1 kg 10 kg or more	1 kg or less but more than 15 g Less than 10kg but more than 1 kg 10 kg or more
3. Uranium-233 (^{233}U)	Unirradiated[b]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
4. Irradiated fuel (The categorization of irradiated fuel in the table is based on international *transport* considerations. The State may assign a different category for domestic use, storage and *transport* taking all relevant factors into account.)			Depleted or natural uranium, thorium or low enriched fuel (less than 10% fissile content)[d, e]	

Note: This table is not to be used or interpreted independently of the text of the entire publication.

[a] All plutonium except that with isotopic concentration exceeding 80% in plutonium-238.

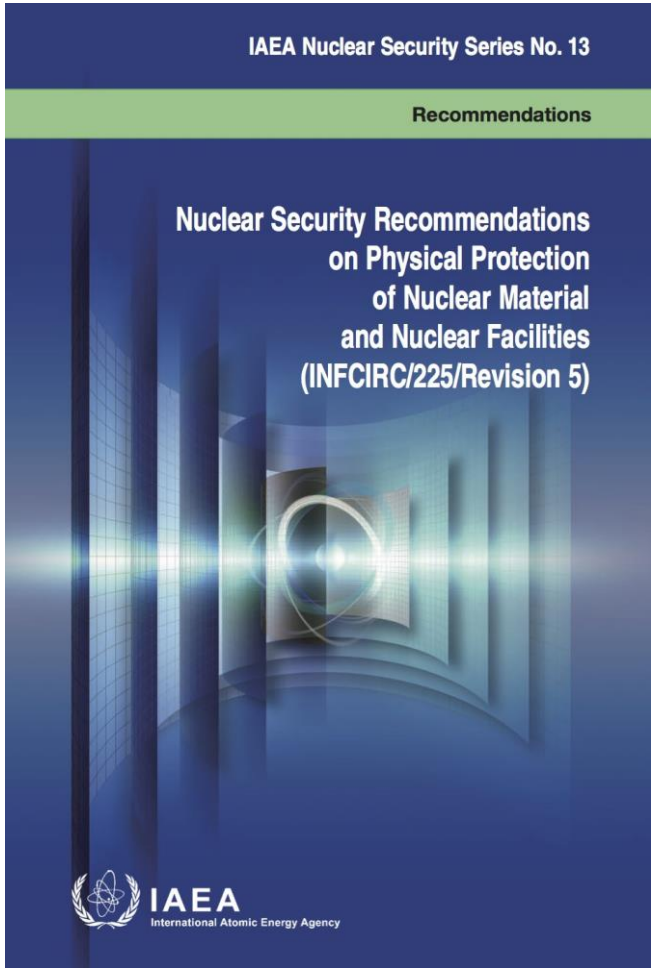
[b] Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gy/h. (100 rad/h) at 1 m unshielded.

[c] Quantities not falling in Category III and natural uranium, depleted uranium and thorium should be protected at least in accordance with prudent management practice.

[d] Although this level of protection is recommended, it would be open to States, upon evaluation of the specific circumstances, to assign a different category of physical protection.

[e] Other fuel which by virtue of its original fissile material content is classified as Category I or II before irradiation may be reduced one category level while the radiation level from the fuel exceeds 1 Gy/h (100 rad/h) at one metre unshielded.

Security at Research Reactors



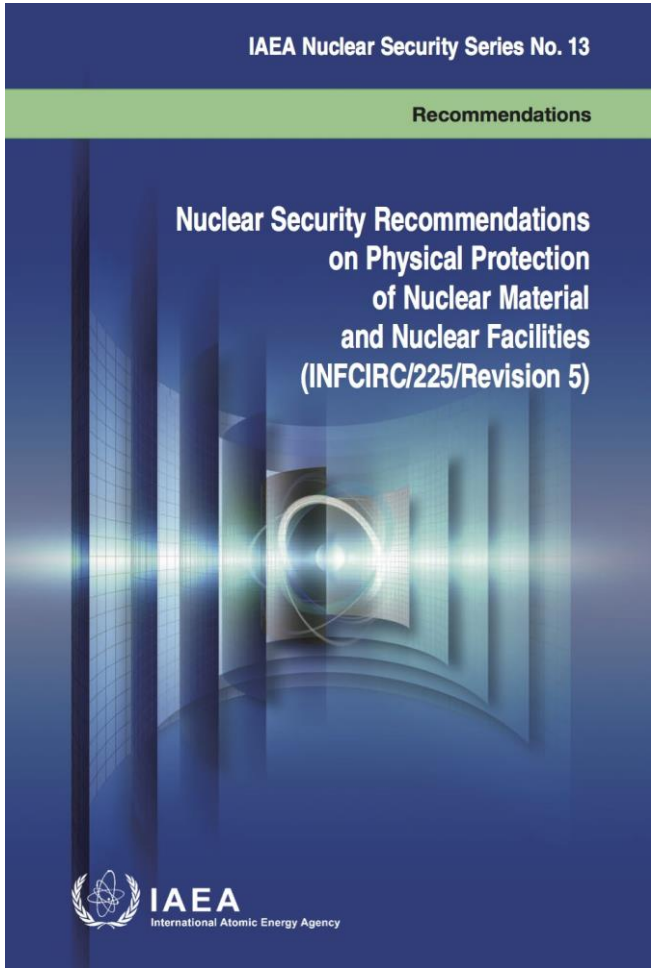
The security concern posed by Research Reactors is commonly represented by:

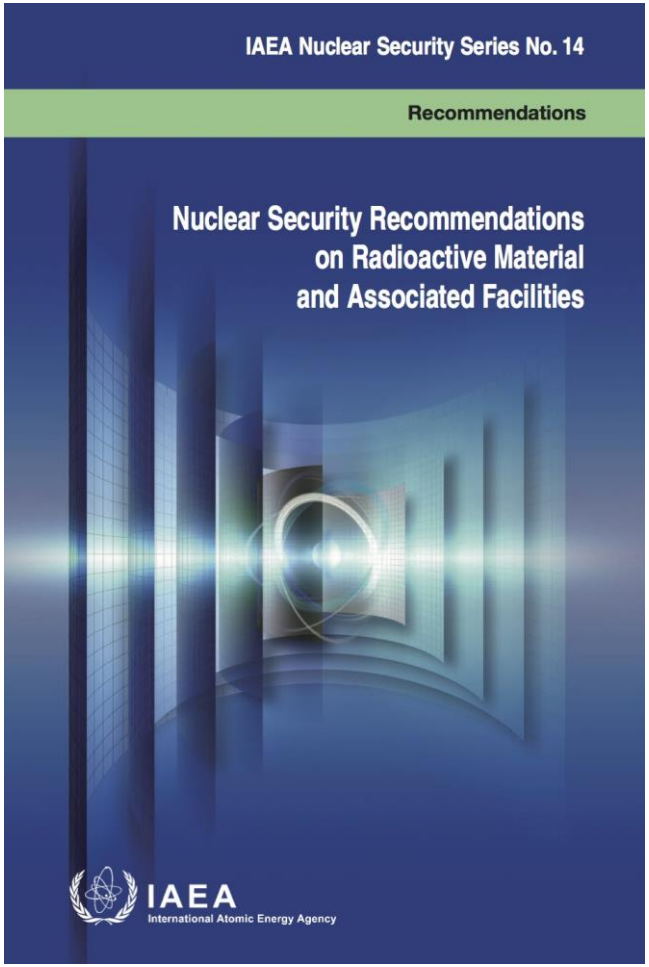
- the category of nuclear material for theft

OR

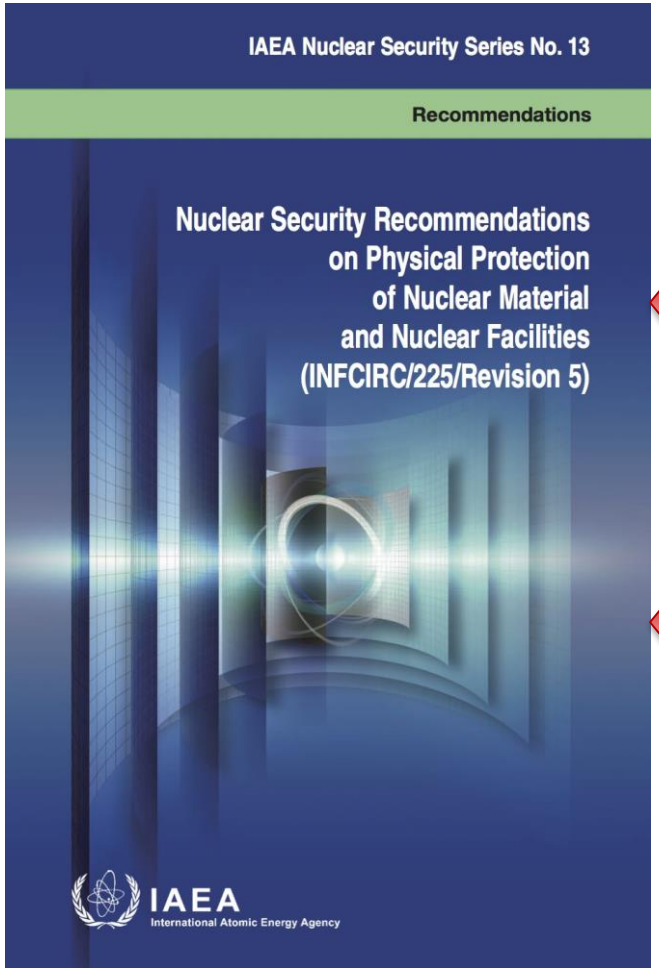
- the thermal power of the reactor for sabotage

Security at Research Reactors



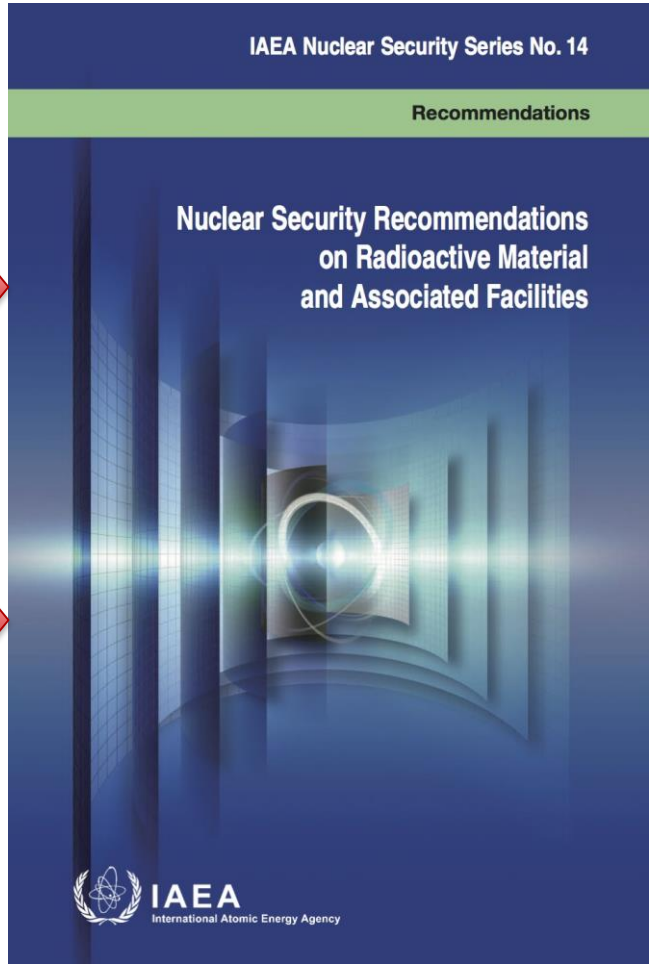


Security at Research Reactors



Irradiated Fuel

Irradiated Uranium Targets



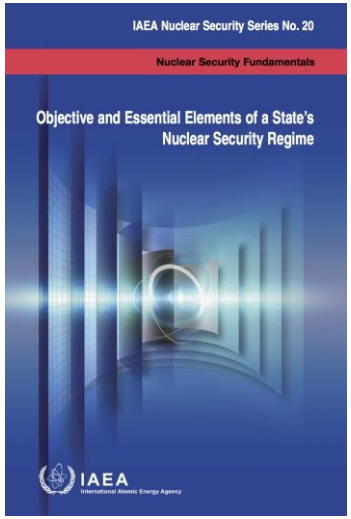
Nuclear Security Risk at RRAF

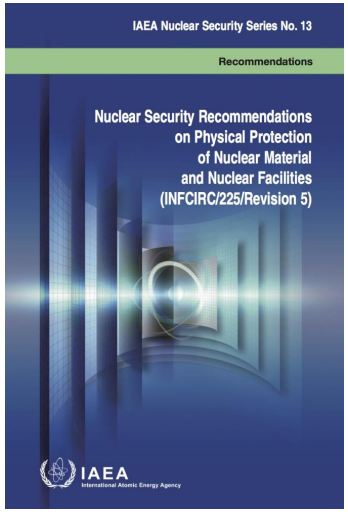
Sandia National Laboratories

- **Research Reactors are commonly co-located with other research or production facilities, such as:**
  - **Waste Treatment and Interim Storage**
  - **Fuel Fabrication**
  - **Radioisotope production**
  - **Gamma Sterilization**

Sources: Wikipedia

Guidance on Risk Management





Objectives and Essential Elements of Nuclear Security Regime

*"…nuclear security regime uses **risk informed approaches**… which take into account:"*

- ***threat***
- ***attractiveness*** *and vulnerability of material*
- ***characteristics*** *of material*
- ***consequences***

Physical Protection of Nuclear Material and Nuclear Facilities

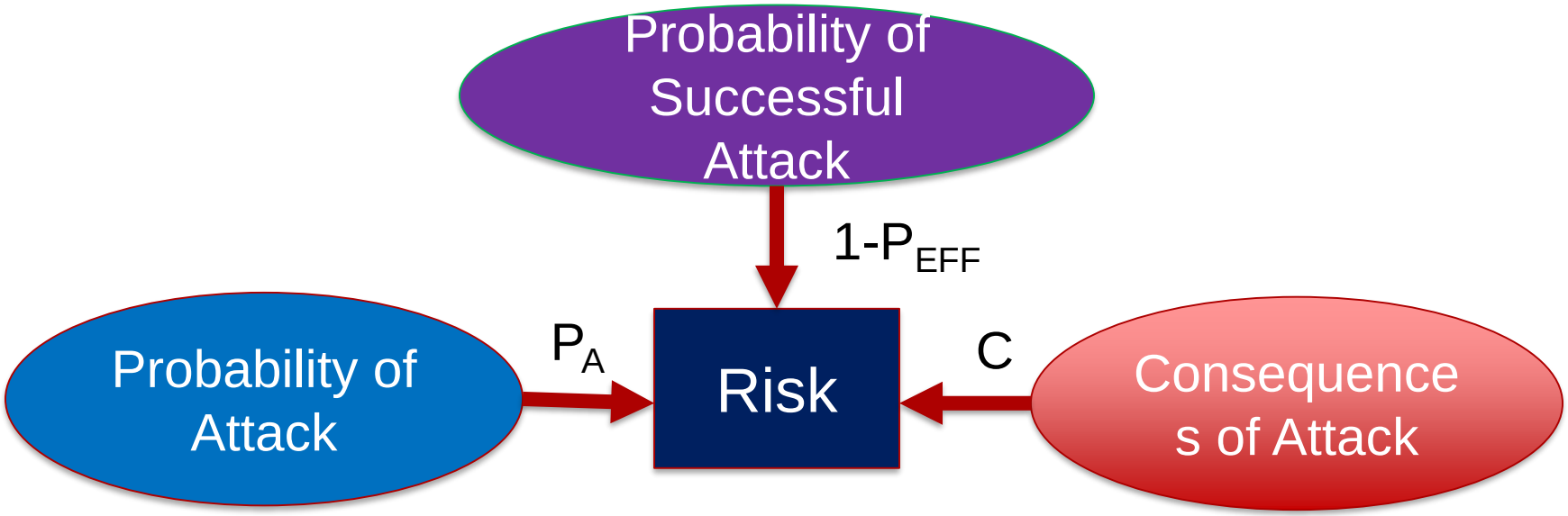
"***Risk*** *can be* ***managed*** *by:"*

- *reducing* ***threat***
- *improving* ***security*** *effectiveness*
- *reducing* ***consequences***

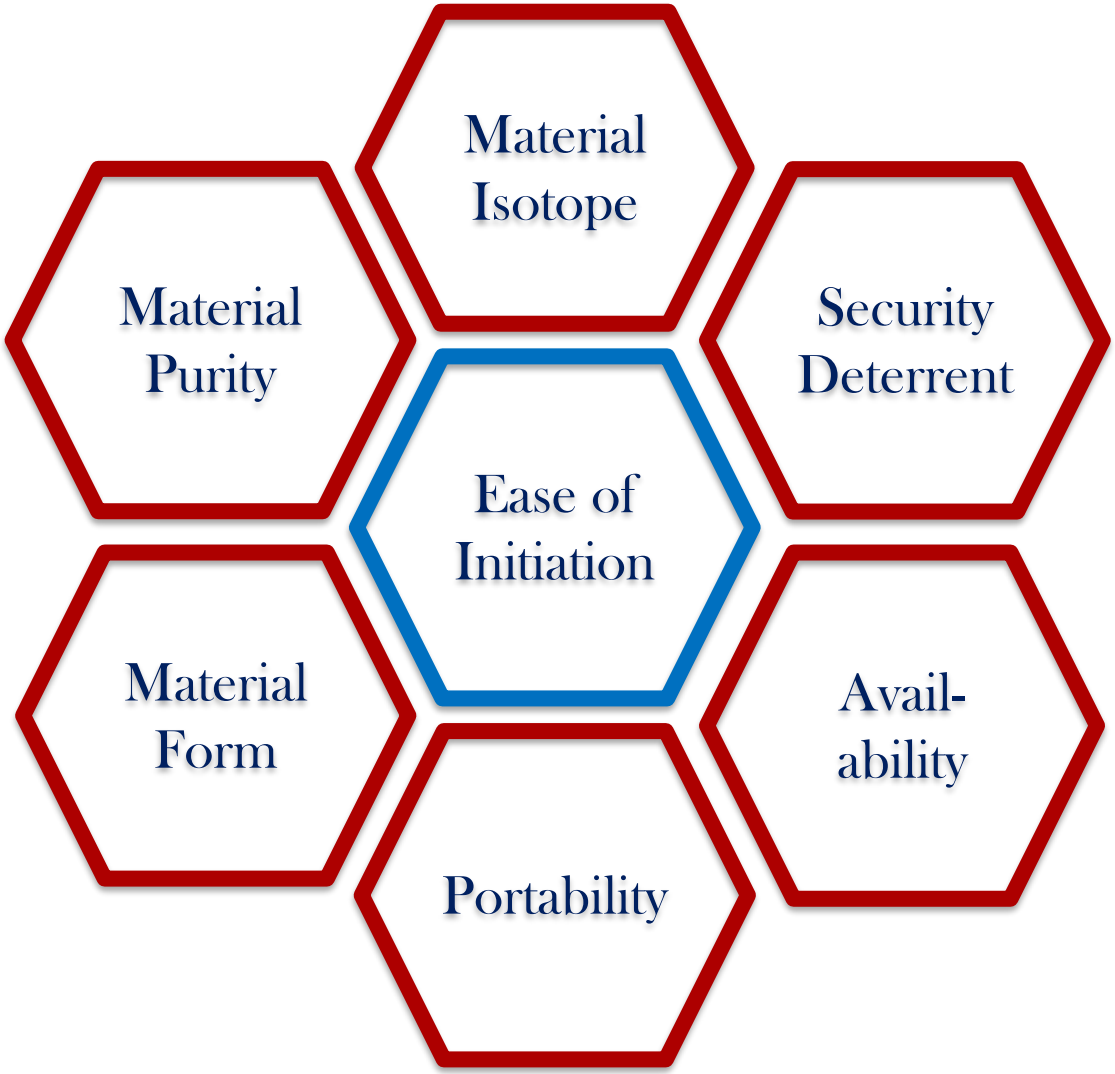
Security Risk

$$R = P * C$$

$$R = P_A * (1 - P_{EFF}) * C$$



Target Attractiveness



Current Estimation of Security Risk at RRAF

The equation:

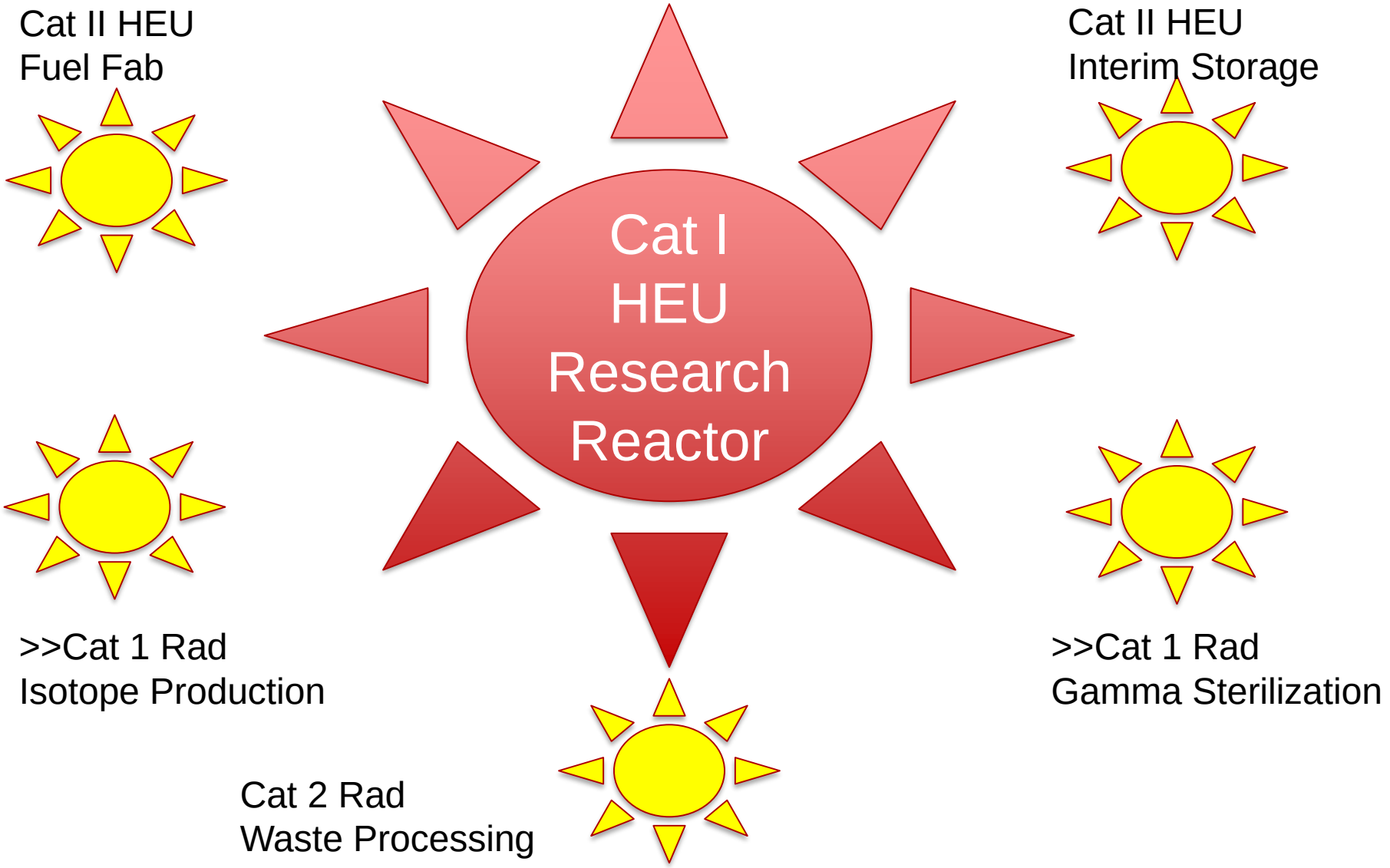
$$\mathbf{Risk = P_A * (1\text{-}P_E) * C}$$

Applied for a specific inventory/target,

- *Usually only the highest consequence inventory*
- *Estimate generally becomes the defacto security risk for site*

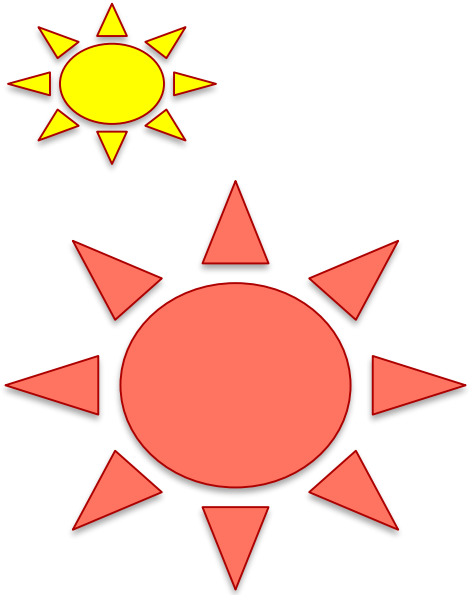
Attractiveness?

Security Concerns at a RRAF



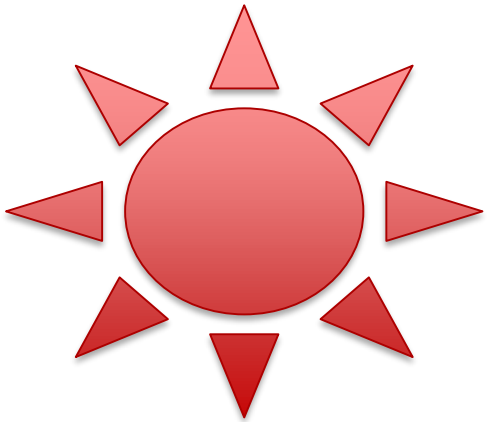
Security Concerns at a RRAF

Cat III LEU
Fuel Fab

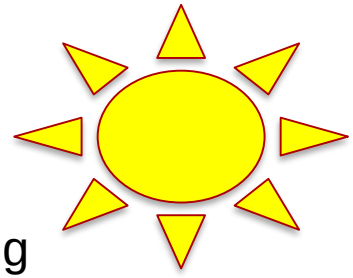


>>Cat 1 Rad
Isotope Production

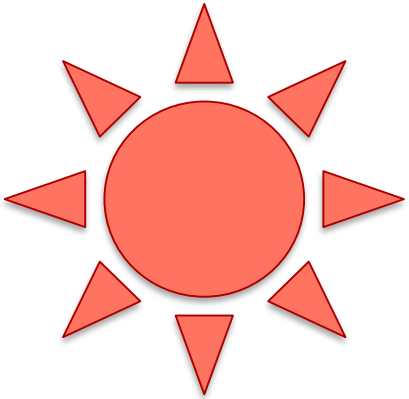
Cat II LEU
Research Reactor

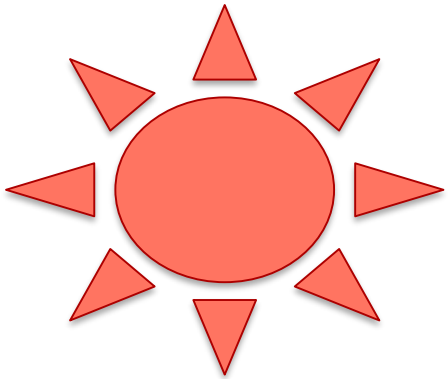


Cat 2 Rad
Waste Processing



Cat III LEU
Interim Storage
>>Cat 1 Rad





>>Cat 1 Rad
Gamma Sterilization

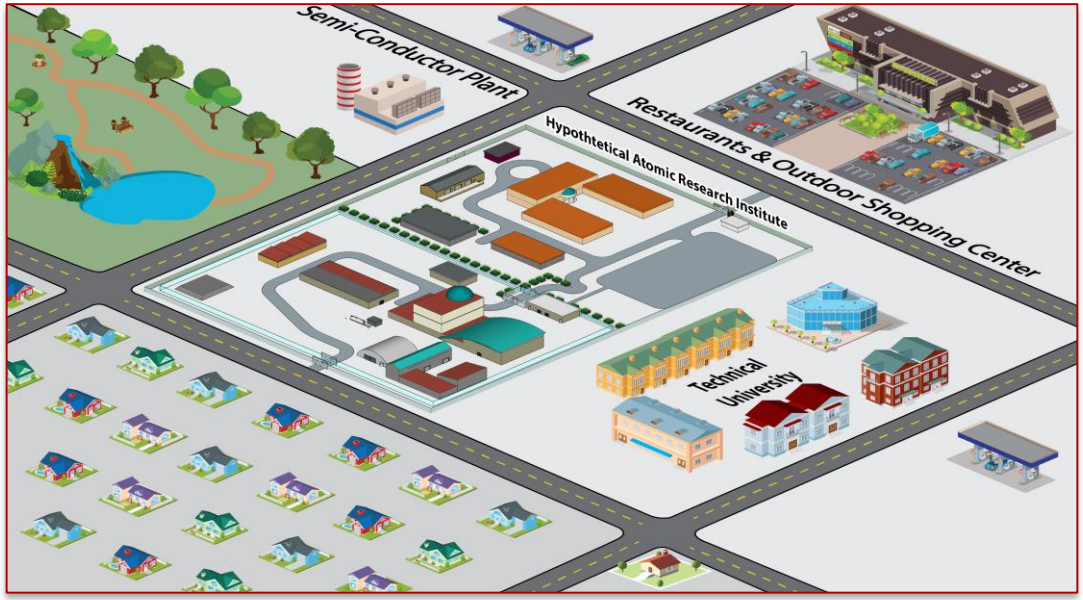
Developing an Estimate of Comprehensive Security Risk at RRAF

- **Diverse Targets**
- **Consequences not comparable**
- **Different Attractiveness**

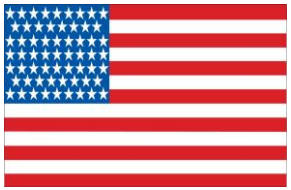
- **Proper Security Resource Allocation**
- **Effective, Cost-Efficient Security System**
- **Increased Relevance of Material Security vs Risk**

IAEA CRP Project

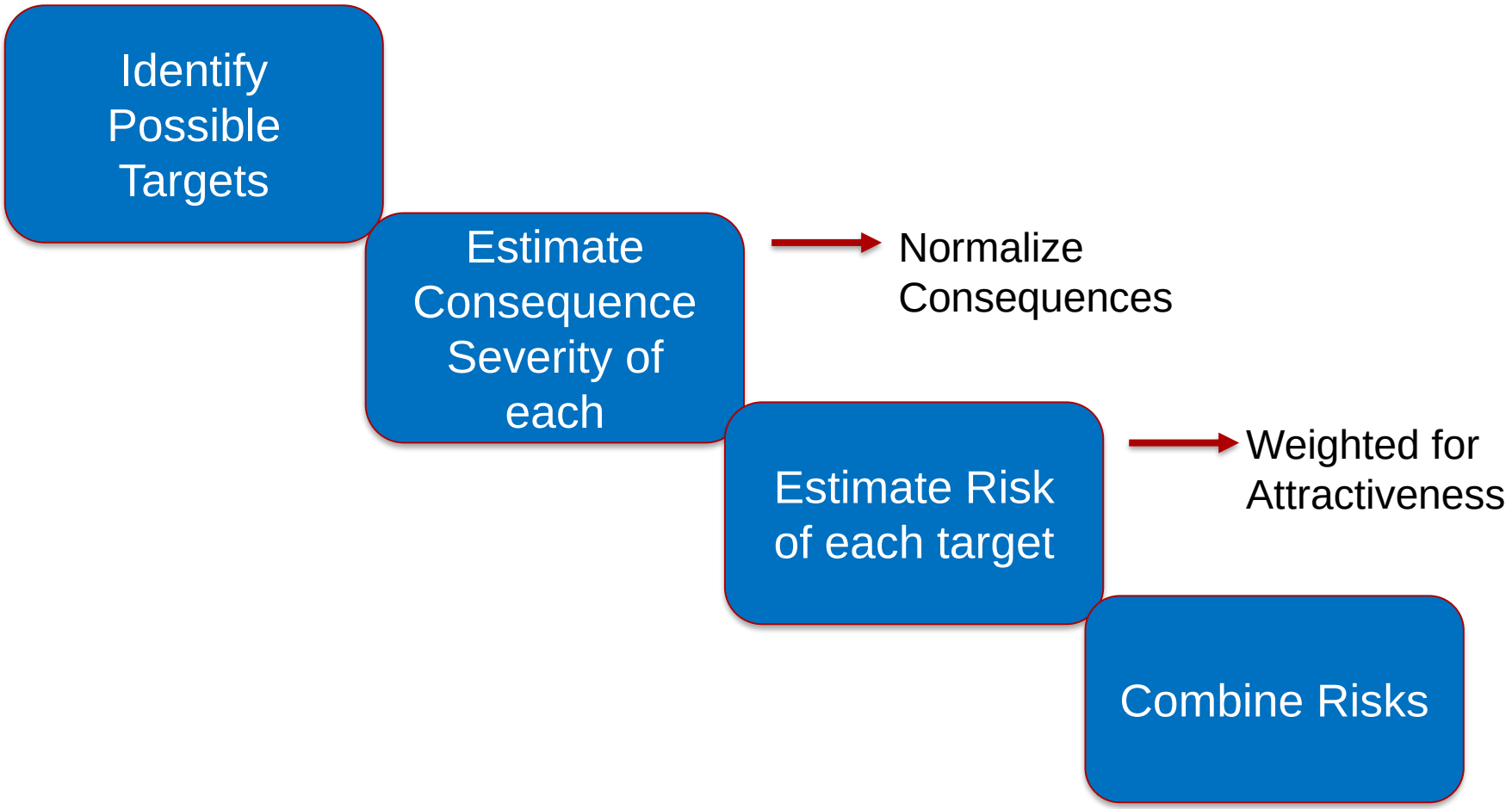
- Develop a Methodology to Estimate Comprehensive Security Risk for a RRAF







IAEA CRP Project

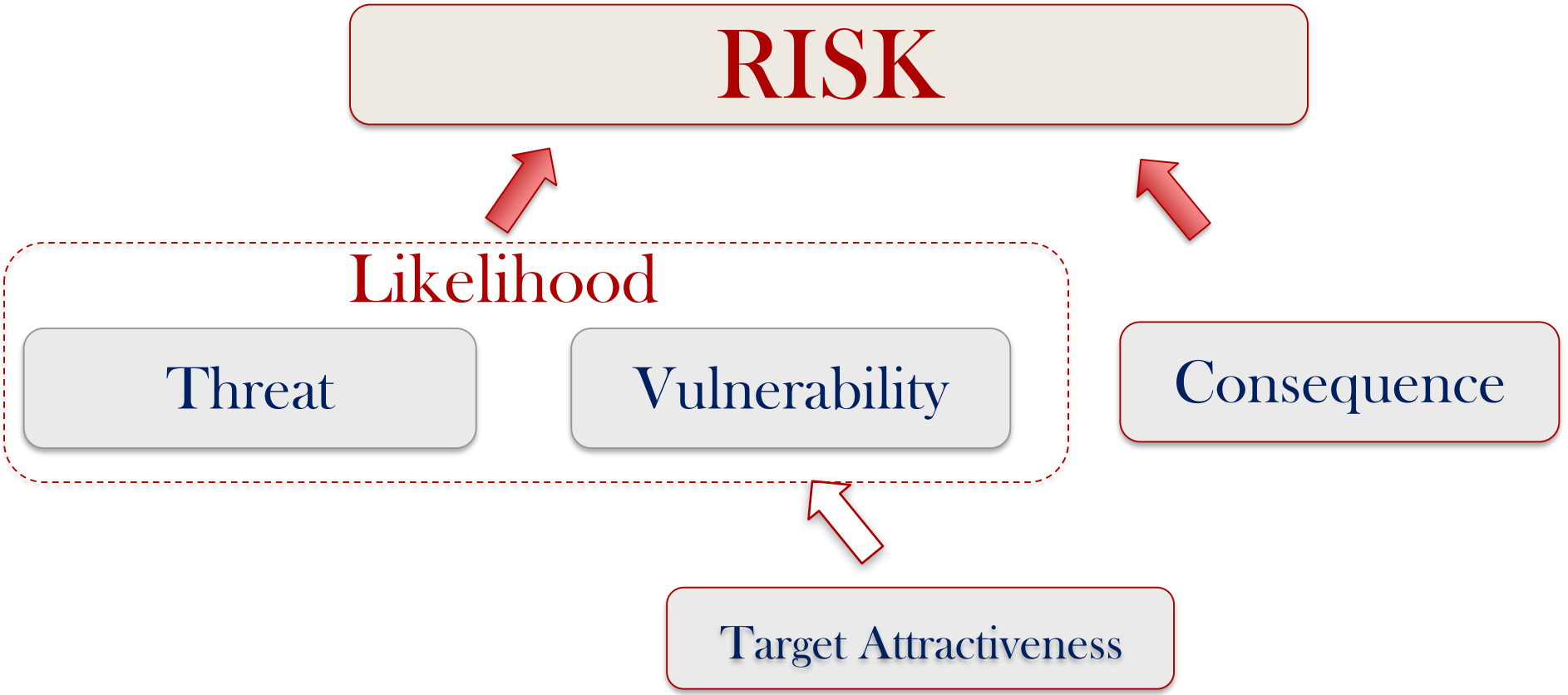


Summary

Sandia National Laboratories

- Security Risk at a RRAF is complex due to the diverse targets, consequences, and attractiveness
- Current Approaches may not sufficiently estimate Site-wide security risk at RRAF
- CRP in place to attempt to develop an approach

Risk Components



Security System Effectiveness?

Comprehensive Security Risk involves:

1. Identifying each target that could lead to unacceptable consequence on RRAF
2. Understanding the security risk posed by each target
   - Potential Consequence
   - Likelihood of Occurrence
     - Attractiveness
     - Security Effectiveness
3. Combining the individual risk estimates into a comprehensive, RRAF-wide security risk